VERIFICATION

The undersigned, of the below address, hereby certifies that he/she well knows both the English and Japanese languages, and that the attached is an accurate English translation of the Japanese Patent application filed on August 7,2002 under No. P2002-230279.

The undersigned declares further that all statements made herein of his/her own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed this 15th day of August, 2007.

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This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Application Number: Japanese Patent Application No.230279/2002

Applicant(s): HAMAMATSU PHOTONICS K.K.

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[Document Name] Specification

[Title of the Invention] OPTICAL CONDENSER DEVICE

[Claims]

[Claim 1] An optical condenser device comprising:

a first light source having a first semiconductor laser array with a plurality of active layers aligned in parallel in a first direction, a first collimator lens for refracting a plurality of beams emitted from the plurality of active layers in a plane perpendicular to the first direction, and a first light path converter for receiving the beams refracted by the first collimator lens to rotate the transverse section of each beam by substantially 90°;

a second light source having a second semiconductor laser array with a plurality of active layers aligned in parallel in a second direction, a second collimator lens for refracting a plurality of beams emitted from the plurality of active layers in a plane perpendicular to the second direction, and a second light path converter for receiving the beams refracted by the second collimator lens to rotate the transverse section of each beam by substantially 90°; and

a first optical combiner for combining the beams from the first light source with the beams from the second light source, the first optical combiner having one or more light light transmitting portions for receiving the beams emitted from the first light path converter and one or more light reflecting portions for receiving the beams emitted from the

second light path converter to combine the beams transmitted through the one or more light transmitting portions with the beams reflected by the one or more light reflecting portions.

[Claim 2] The optical condenser device according to claim 1, wherein the plurality of active layers are aligned at intervals of no more than 500 μm.

[Claim 3] The optical condenser device according to claim 1, wherein the first optical combiner has a plurality of the light transmitting portions which are in one-to-one correspondence with the active layers of the first light source, and a plurality of the light reflecting portions which are in one-to-one correspondence with the active layers of the second light source,

wherein the plurality of light transmitting portions and the plurality of light reflecting portions are both strip-like in form, and

wherein the first optical combiner is a flat plate having the plurality of light transmitting portions and the plurality of light reflecting portions positioned alternately.

[Claim 4] The optical condenser device according to claim 3, wherein the first optical combiner is inclined at an angle of 45° with respect to the central axes of both the beams emitted from the active layers of the first light source and the beams emitted from the active layers of the second light source,

wherein the front surface of the first optical combiner

opposes the first light source, and

wherein the back side of the first optical combiner opposes the second light source.

[Claim 5] The optical condenser device according to claim 1, further comprising:

a third light source having a third semiconductor laser array with a plurality of active layers aligned in parallel in a third direction, a third collimator lens refracting a plurality of beams emitted from the plurality of active layers in a plane perpendicular to the third direction, and a third light path converter for receiving the beams refracted by the third collimator lens and rotating the transverse section of each beam by substantially 90°; and

a second optical combiner having one or more light transmitting portions for receiving the beams combined by the first optical combiner and one or more light reflecting portions for receiving the beams emitted from the third light path converter to combine the beams transmitted through the one or more light transmitting portions and the beams reflected by the one or more light reflecting portions.

[Claim 6] The optical condenser device according to claim 5, wherein the second optical combiner has a plurality of the light reflecting portions which are in one-to-one correspondence with the active layers of the third light source,

wherein the one or more light transmitting portions and

the plurality of light reflecting portions are both strip-like in form, and

wherein the second optical combiner is a flat plate having the one or more light transmitting portions and the plurality of light reflecting portions positioned alternately.

[Claim 7] The optical condenser device according to claim 1, further comprising:

a third light source having a third semiconductor laser array with a plurality of active layers aligned in parallel in a third direction, a third collimator lens refracting a plurality of beams emitted from the plurality of active layers in a plane perpendicular to the third direction, and a third light path converter receiving the beams refracted by the third collimator lens and rotating the transverse section of each beam by substantially 90°; and

a second optical combiner having one or more light transmitting portions for receiving the beams emitted from the third light path converter and one or more light reflecting portions for receiving the beams combined by the first optical combiner to combine the beams transmitted through the one or more light transmitting portions and the beams reflected by the one or more light reflecting portions.

[Claim 8] The optical condenser device according to claim 7, wherein the second optical combiner has a plurality of the light transmitting portions which are in one-to-one correspondence with the active layers of the third light

source,

wherein the plurality of light transmitting portions and the one or more light reflecting portions are both strip-like in form, and

wherein the second optical combiner is a flat plate having the plurality of light transmitting portions and the one or more light reflecting portions positioned alternately.

[Claim 9] The optical condenser device according to claim 6 or 8, wherein the second optical combiner is inclined at an angle of 45° with respect to the central axes of both the beams combined by the first optical combiner and the beams emitted from the active layers of the third light source,

wherein the front surface of the second optical combiner opposes the first optical combiner, and

wherein the back surface of the second optical combiner opposes the third light source.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

This invention relates to an optical condenser device that increases the density of beams emitted from a semiconductor laser array.

[0002]

[Prior Art]

Semiconductor laser arrays are known as laser elements with high output. FIG. 11 is a perspective view showing an

example of a semiconductor laser array. As shown in FIG. 11, in a semiconductor laser array 12, a plurality of active layers 14 are aligned in parallel.

[0003]

FIG. 12 illustrates the spreading angles of a beam emitted from an active layer 14. FIG. 12(a) is a side view illustrating the spreading angles of a beam. FIG. 12(b) is a plan view illustrating the spreading angles of a beam. The x-axis, y-axis, and z-axis indicate the longitudinal direction, horizontal direction, and vertical direction, respectively, of semiconductor laser array. For each beam emitted from an active layer 14, the spreading angle in the vertical direction is 30° (FIG. 12(a)) and the spreading angle in the horizontal direction is 8°(FIG. 12(b)).

[0004]

In consideration of an application wherein lenses, etc., are used to condense beams from a semiconductor laser array onto an optical fiber, etc., it is preferable to restrain the spread of the respective components of the vertical direction and the horizontal direction of each beam. The vertical direction components of the beams can be collimated readily using a collimator lens.

[0005]

[Problem to be Solved by the Invention]

On the other hand, it is not easy to restrain the spread of the beams in the horizontal direction. This is because

when a plurality of active layers 14 are positioned close to each other, the beams emitted by these active layers 14 cross each other immediately. A method of increasing the interval between the active layers may be considered for preventing the crossing of the beams. However, a high beam density cannot be anticipated in this case.

[0006]

A problem of the present invention is to provide an optical condenser device wherein beams emitted from active layers are difficult to cross each other even if the active layers of the semiconductor laser array are close to each other.

[0007]

[Means for Solving the Problem]

An optical condenser device in accordance with the present invention comprises a first light source, a second light source, and a first optical combiner. The first light source has a first semiconductor laser array with a plurality of active layers aligned in parallel in a first direction, a first collimator lens for refracting a plurality of beams emitted from the plurality of active layers in a plane perpendicular to the first direction, and a first light path converter for receiving the beams refracted by the first collimator lens to rotate the transverse section of each beam by substantially 90°. The second light source has a second semiconductor laser array with a plurality of active layers aligned in parallel in a second

direction, a second collimator lens for refracting a plurality of beams emitted from the plurality of active layers in a plane perpendicular to the second direction, and a second light path converter for receiving the beams refracted by the second collimator lens to rotate the transverse section of each beam by substantially 90°. Here, the transverse section of a beam refers to a cross section that is substantially perpendicular to the central axis of that beam. The first optical combiner combines the beams from the first light source and the beams from the second light source. The first optical combiner has one or more light transmitting portions for receiving the beams emitted from the first light path converter, and one or more light reflecting portions for receiving the beams emitted from the second light path converter. The first optical combiner combines the beams transmitted through the one or more light transmitting portions and the beams reflected by the one or more light reflecting portions.

[0008]

The spread of each beam within a plane perpendicular to the direction of alignment of the active layers is restrained by the refraction of the collimator lens. Rotating the transverse section of each beam by substantially 90° suppresses the spread of the beam in the direction of alignment of the active layers. Accordingly, adjacent beams become unlikely to cross each other. As a result, the active layers can be positioned closely at intervals of no more than

500 μm.

[0009]

[Embodiments of the Invention]

Embodiments of this invention will now be described with reference to the accompanying drawings. In the description of the drawings, the same elements will be provided with the same symbols and redundant descriptions will be omitted. The dimensional proportions in the drawings do not necessarily match those of the description for the sake of convenience to show the drawings.

[0010]

(First Embodiment)

FIG. 1 is a schematic perspective view showing an optical condenser device in accordance with the first embodiment of the invention. The condenser device of this embodiment is configured of a first light source 10, a second light source 20, and an optical combiner 30.

[0011]

First light source 10 is configured of a first semiconductor laser array 12, a first collimator lens 16, and a first light path converter 18. First semiconductor laser array 12 has a plurality of active layers 14. First collimator lens 16 refracts and collimates the vertical direction (z-direction) components of the beams emitted from the respective active layers 14. Light path converter 18 rotates the transverse section of each of these collimated beams by substantially

90°.

[0012]

FIG. 2 is a view showing a front end surface (light outputting surface) of first semiconductor laser array 12. FIG. 3 is a view showing a front end surface of active layer 14. Active layers 14 of laser array 12 are aligned, within a width of 1 cm, in a single row along the y-direction at intervals of 500 μm. The cross section of each active layer 14 has a width of 100 μm and a thickness of 1μm. As shown in FIG. 12, the angles of spread of the beam emitted from active layer 14 is 30°in the thickness direction of active layer 14, in other words, in the vertical direction (z-direction) and 8°in the width direction of active layer 14, in other words, in the horizontal direction (y-direction).

[0013]

FIG. 4 is a perspective view showing a cylindrical lens as an example of first collimator lens 16. Front surface and back surface of cylindrical lens 16 are cylindrical surfaces having a generating line along the y-direction. Though cylindrical lens 16 does not provide a refractive action in the plane containing the generating line direction, it provides a refractive action in the plane perpendicular to the generating line. As shown in FIG. 4, the length in the generating line direction, that is, the y-direction is 12 mm, the length in the x-direction is 0.2 mm, and the length in the z-direction is 0.6 mm. Thus cylindrical lens 16 is elongated along the

y-direction. Thus all the beams emitted from these active layers 14 enter cylindrical lens 16.

[0014]

Since the beams emitted from active layers 14 are large in the angle of spread in the vertical direction, as mentioned above, the spread of the beams must be restrained by using refraction in order to improve the condensing efficiency. Cylindrical lens 16 is thus set so that the generating line of it will be orthogonal to the vertical direction (z-direction) of semiconductor laser array 12. The beams emitted from active layers 14 can thereby be refracted and collimated within a plane perpendicular to the generating line of cylindrical lens 16. In order for efficient collimation, cylindrical lens 16 is positioned close to active layers 14.

[0015]

FIG. 5 is a perspective view showing an example of first light path converter 18. First light path converter 18 is formed of glass, quartz, or other light transmitting material. The length in the x-direction is 1.5 mm, the length in the y-direction is 12 mm, and the length in the z-direction is 1.5 mm. Light path converter 18 has a shape that is elongated along the y-direction. Thus all the beams emitted from cylindrical lens 16 enter light path converter 18. Light path converter 18 has an input surface 180 and an output surface 181 that oppose each other. Input surface 180 has a plurality of cylindrical surfaces that are aligned in parallel. The

width of each cylindrical surface is 0.5 mm. These cylindrical surfaces extend at an angle of 45° with respect to the y-direction. The number of these cylindrical surfaces is equal to the number of active layers 14. These cylindrical surfaces are thus in one-to-one correspondence with active layers 14. Reflecting surface 181 likewise has a plurality of cylindrical surfaces of 0.5 mm width aligned in parallel. These cylindrical surfaces also extend at an angle of 45° with respect to the y-direction and are in one-to-one correspondence with active layers 14.

[0016]

Another example of a light path converter is described, for example, in Japanese Patent Publication No. 3071360.

[0017]

Second light source 20 is configured of a second semiconductor laser array 22, a second cylindrical lens 26, and a second light path converter 28 as well as first light source 10. Second semiconductor laser array 22, second cylindrical lens 26, and second light path converter 28 are the same in configuration as first semiconductor laser array 12, first cylindrical lens 16, and first light path converter 18, respectively. Detailed description of these components thus will be omitted. However, the orientation of second light source 20 differs from the orientation of first light source 10. More specifically, whereas first laser array 12 has the plurality of active layers 14 aligned in parallel in the

y-direction, second laser array 22 has a plurality of active layers 24 aligned in parallel in the x-direction. Second cylindrical lens 26 is positioned along the x-direction in correspondence to active layers 24. Second light path converter 28 is also positioned along the x-direction in correspondence to active layers 24.

[0018]

FIG. 6 is a plan view showing optical combiner 30. Optical combiner 30 is configured of a flat plate having a plurality of light transmitting portions 32 and a plurality of light reflecting portions 34 positioned alternately. Light transmitting portions 32 and light reflecting portions 34 have a strip-like shape with the same dimension. Optical combiner 30 is a plate mainly made of light transmitting material. Light transmitting portions 32 receive the beams emitted from first light path converter 18. A light transmitting thin film is formed on each light transmitting portion 32. Meanwhile, light reflecting portions 34 receive the beams emitted from second light path converter 28. A light reflecting thin film is formed on each light reflecting portion 34. Optical combiner 30 is inclined at an angle of 45° with respect to central axes 15 of the beams emitted from active layers 14 of first light source 10. Optical combiner 30 is also inclined at an angle of 45° with respect to central axes 15 of the beams emitted from active layers 24 of second light source 20. The front surface of optical combiner 30 opposes

first light source 10 and the back surface of optical combiner 30 opposes second light source 20. Light transmitting portions 32 are in one-to-one correspondence with active layers 14 of first light source 10. Meanwhile, light reflecting portions 34 are in one-to-one correspondence with active layers 24 of second light source 20.

[0019]

Because optical combiner 30, first light source 10, and second light source 20 are arranged as described above, the beam emitted from first light source 10 is transmitted through the light transmitting portion 32 of optical combiner 30. Meanwhile, the beam emitted from second light source 20 is reflected by the light reflecting portion 34 of optical combiner 30. As a result, these beams propagate in the same direction at the back surface side of optical combiner 30. These beams are mixed into a combined light 91 (FIG. 1).

[0020]

The actions of the condenser device of the present embodiment will now be described with reference to FIG. 7 and FIG. 8. Here, FIG. 7(a) shows the transverse sections (the emission patterns) of the lights generated in active layers 14 or 24 and emitted therefrom. FIG. 7(b) shows the transverse sections of the beams emitted from active layers 14 or 24 and then transmitted through cylindrical lens 16 or 26. FIG. 7(c) shows the transverse sections of the beams transmitted through cylindrical lens 16 or 26 and then

transmitted though light path converter 18 or 28. FIG. 8(a) shows the transverse sections which are taken perpendicularly to central axes 15 of the beams emitted from first light source 10. FIG. 8(b) shows the transverse sections which are taken perpendicularly to central axes 15 of the beams emitted from second light source 20. FIG. 8(c) shows the transverse section of combined light 91 of the beams from first light source 10 and the beams from second light source 20, which transverse section is taken perpendicularly to the central axe 15 of combined light 91.

[0021]

Each beam has a cross-sectional shape that is close to a circle on its emission from active layers 14 or 24 (FIG. 7(a)). When being transmitted through cylindrical lens 16 or 26, each beam is refracted in a plane perpendicular to the direction of the generating line of cylindrical lens 16 or 26. As a result, the vertical direction components of the beams are collimated (FIG. 7(b)). Meanwhile, since the horizontal direction components of the beams are not subject to the refraction, the beams do not change in the angle of spread in the horizontal direction.

[0022]

The beams which transmit through first cylindrical lens 16 enter first light path converter 18. Light path converter 18 rotates the transverse sections of these beams by substantially 90° about central axes 15 of the respective

beams (FIG. 7(c)). The beams collimated in the vertical direction are thereby converted into beams that are collimated in the horizontal direction. As a result, the beams no longer diverge in the horizontal direction. The crossing of adjacent beams each other can thus be avoided.

[0023]

As with the beams from the first light source, the vertical direction components of the beams emitted from active layers 24 of second light source 20 are collimated upon transmission through second cylindrical lens 26. Upon transmission through second light path converter 28, these beams are converted into beams that are collimated in the horizontal direction. As a result, in also second light source 20, the beams do not diverge in the horizontal direction, and the crossing of adjacent beams each other can thus be avoided.

[0024]

The beams emitted from light path converter 18 of first light source 10 are transmitted through light transmitting portions 32 of optical combiner 30. The beams emitted from the respective active layers 14 are transmitted through the corresponding light transmitting portions 32 without crossing each other (FIG. 8(a)). Meanwhile, the beams emitted from light path converter 28 of second light source 20 are reflected by light reflecting portions 34 of optical combiner 30. The beams emitted from the respective active layers 24 are

reflected by the corresponding light reflecting portions 34 without crossing each other (FIG. 8(b)).

[0025]

The beams transmitted through the light transmitting portions 32 and the beams reflected by light reflecting portions 34 form a combined light 91. The optical density of combined light 91 equals to the sum of the optical density of the beams emitted from first light source 10 and the optical density of the beams emitted from second light source 20 (FIG. 8(c)). As a result, the optical density is increased.

[0026]

The advantages of the condenser device of the present embodiment will now be described. According to the condenser device of the present embodiment, since the beams emitted from the semiconductor laser array do not diverge in the horizontal direction (y-direction), adjacent beams will not cross each other. Even if the plurality of active layers of the semiconductor laser array are positioned close to each other, adjacent beams will not cross each other. This enables close arrangement of the active layers, and therefore higher optical density can be obtained.

[0027]

(Second Embodiment)

An optical condenser device of a second embodiment of the invention will now be described. FIG. 9 is a perspective view showing an optical condenser device of the present

embodiment. Whereas the optical condense device of the first embodiment is configured of two light sources and a single optical combiner, the optical condense device of the present embodiment is configured of three light sources and two optical combiners. Whereas the beams emitted from the two light sources are combined in the optical condense device of the first embodiment, the beams emitted from the three light sources are combined in the optical condense device of the present embodiment.

[0028]

The condenser device of the present embodiment is configured of a first light source 10, a second light source 20, a third light source 60, a first optical combiner 30, and a second optical combiner 80. The arrangements and positioning of first light source 10, second light source 20, and first optical combiner 30 have been already described in relation to the first embodiment.

[0029]

Third light source 60 is configured of a third semiconductor laser array 62, a third collimator lens 66, and a third light path converter 68. Third semiconductor laser array 62 has a plurality of active layers 64. Third collimator lens 66 refracts and collimates the vertical direction components of the beams emitted from the respective active layers 64. Third light path converter 68 rotates the transverse sections of these collimated beams by substantially

90°. The configurations of third semiconductor laser array 62, third collimator lens 66, and third light path converter 68 are the same as those of semiconductor laser arrays 12 and 22, collimator lenses 16 and 26, and light path converters 18 and 28, respectively. Accordingly, redundant descriptions will be omitted.

[0030]

The orientation of third light source 60 is the same as the orientation of second light source 20 and differs from that of first light source 10. Whereas first semiconductor laser array 12 has a plurality of active layers 14 aligned in parallel in the y-direction, second and third semiconductor laser arrays 22 and 62 have pluralities of active layers 24 and 64 aligned in parallel in the x-direction. Third cylindrical lens 66 is positioned along the x-direction in correspondence to active layers 64. Likewise, third light path converter 68 is also positioned along the x-direction.

[0031]

As is described with the first embodiment, the beam emitted from first light source 10 is transmitted through the light transmitting portion of first optical combiner 30. Meanwhile, the beam emitted from second light source 20 is reflected by the light reflecting portion of first optical combiner 30. As a result, these beams propagate in the same direction at the back surface side of first combiner 30. These beams are mixed into a combined light 91 (FIG. 9).

[0032]

Second optical combiner 80 has the same configuration as that of first optical combiner 30. That is, second optical combiner 80 is configured of a flat plate having a plurality of light transmitting portions 32 and a plurality of light reflecting portions 34 positioned alternately and in parallel shown in FIG. 6. The light transmitting portions 32 of second optical combiner 80 receive combined light 91 emitted from first optical combiner 30. Meanwhile, the light reflecting portions 34 of second optical combiner 80 receive beams emitted from third light path converter 68. Second optical combiner 80 is inclined at an angle of 45° with respect to the central axis of combined light 91. Second optical combiner 80 is also inclined at an angle of 45° with respect to the central axes of the beams emitted from active layers 64 of third light source 60. The front surface of optical combiner 80 opposes first optical combiner 30 and the back surface of second optical combiner 80 opposes third light source 60. The light reflecting portions 34 of second optical combiner 80 are in one-to-one correspondence with active layers 64 of third light source 60.

[0033]

The combined light 91 is transmitted through the light transmitting portions of second optical combiner 80. Meanwhile, the beam emitted from third light source 60 is reflected by the light reflecting portion of second optical

combiner 80. As a result, these beams propagate in the same direction at the back surface side of second optical combiner 80. These beams are mixed into a combined beam 95.

[0034]

The actions of the condenser device of the present embodiment will now be described. FIG. 10(a) shows the transverse sections which are taken perpendicularly to central axe of the beams emitted from first light source 10. FIG. 10(b) shows the transverse sections which are taken perpendicularly to their central axe of the beams emitted from second light source 20, which transverse sections. FIG. 10(c) shows the transverse sections which are taken perpendicularly to their central axe of the beams emitted from third light source 60. FIG. 10(d) shows the transverse section of combined light 91 of the beams from first light source 10 and the beams from second light source 20, which transverse section is taken perpendicularly to the central axis of combined light 91. FIG. 10(e) shows the transverse section of combined beam 95 of combined light 91 and the beams emitted from third light source 60, which transverse section is taken perpendicularly to the central axis of combined beam 95.

[0035]

As shown in FIG. 7(a), each beam has a cross-sectional shape that is close to a circle on its emission from active layers 14, 24 or 64. When being transmitted through the

corresponding cylindrical lens 16, 26 or 66, each beam is subject to the refraction in a plane perpendicular to the direction of the generating line of cylindrical lens 16, 26 or 66. As a result, the vertical direction components of the beams are collimated as shown in FIG. 7(b). Meanwhile, since the horizontal direction components of the beams are not subject to the refraction, the beams do not change in the angle of spread in the horizontal direction.

[0036]

After the transmission through cylindrical lenses 16, 26 and 66, the beams enter light path converters 18, 28 and 68. Light path converters 18, 28 and 68 rotate the transverse sections of these beams by substantially 90° about central axes of the respective beams (FIG. 7(c)). The beams collimated in the vertical direction are thereby converted into beams that are collimated in the horizontal direction. As a result, the beams no longer diverge in the horizontal direction. The crossing of adjacent beams each other can thus be avoided.

[0037]

The beams emitted from light path converter 18 of first light source 10 are transmitted through light transmitting portions 32 of first optical combiner 30. The beams emitted from the respective active layers 14 are transmitted through the corresponding light transmitting portions 32 without crossing each other (FIG. 10(a)). Meanwhile, the beams

emitted from light path converter 28 of second light source 20 are reflected by light reflecting portions 34 of first optical combiner 30. The beams emitted from the respective active layers 24 are reflected by the corresponding light reflecting portions 34 without crossing each other (FIG. 10(b)).

[0038]

The beams transmitted through light transmitting portions 32 and the beams reflected by light reflecting portion 34s form a combined light 91. The optical density of the combined beam equals to the sum of the density of the beams emitted from first light source 10 and the density of the beams emitted from second light source 20 (FIG. 10(d)).

[0039]

Combined light 91 formed by first optical combiner 30 is transmitted through the light transmitting portions 32 of second optical combiner 80. Meanwhile, the beams emitted from light path converter 68 of third light source 60 are reflected by the light reflecting portions 34 of second optical combiner 80. The beams emitted from the respective active layers 64 are reflected by the corresponding light reflecting portions 34 without crossing each other (FIG. 10(c)).

[0040]

Combined light 91 transmitted through the light transmitting portions 32 and the beams reflected by the light reflecting portions 34 form a combined beam 95. The optical density of combined beam 95 equals to the sum of the

density of the beams emitted from first light source 10, the density of the beams emitted from second light source 20 and the density of the beams emitted from third light source 60. The optical density is thus made very high (FIG. 10(e)).

[0041]

The advantages of the condenser device of the present embodiment will now be described. According to the condenser device of the present embodiment, since the beam emitted from each semiconductor laser array of light source does not diverge in the horizontal direction (y-direction), adjacent beams will not cross each other. Even if the plurality of active layers of the semiconductor laser array are positioned closed to each other, adjacent beams will not cross each other. This enables concentrating the beams from the three light sources as well as close positioning of the active layers, and therefore much higher density can be obtained.

[0042]

The invention has been explained in detail hereinabove based on the embodiments thereof. However, the invention is not limited to the embodiments, and various modifications are possible without departing from the scope of the invention.

[0043]

For example, in the embodiments described above, a cylindrical lens is cited as an example of a collimator lens; however, a glass fiber lens or a SELFOC lens, etc., may be

used instead. Also, this invention may be an optical condenser device using four or more light sources.

[0044]

In the second embodiment, combined light 91 is transmitted through second optical combiner 80 and the beams emitted from third light source 60 are reflected by second optical combiner 80 to form combined beam 95. Alternatively, combined beam 95 may be formed by causing the beams emitted from third light source 60 to be transmitted through second optical combiner 80 and causing combined light 91 to be reflected by second optical combiner 80. In this case, the light transmitting portions of second optical combiner 80 receive the beams emitted from third light path converter 68. Also, the light reflecting portions of second optical combiner 80 receive combined light 91. The light transmitting portions of second optical combiner 80 are put in one-to-one correspondence with active layers 64 of semiconductor laser array 62.

[0045]

[Effects of the Invention]

The optical condenser device in accordance with the invention uses a collimator lens to refract beams emitted from a semiconductor laser array, and then rotates the transverse sections of the beams by substantially 90° using a light path converter. The spread of the beams in the direction in which the active layers are aligned can thereby be restrained and the

crossing of adjacent beams can be avoided. Since the active layers can thus be positioned closely, a high optical density can be obtained. The condenser device of this invention can thus be applied favorably to the fields of solid laser pumping, printing, material processing, and medical applications that require high optical density.

[Brief Description of the Drawings]

[Fig. 1] is a schematic perspective view showing an optical condenser device of a first embodiment of the present invention.

[FIG. 2] is a view showing a front end surface (light outputting surface) of a semiconductor laser array used in the optical condenser device of the first embodiment of the present invention.

[FIG. 3] is a view showing a front end surface of an active layer of the semiconductor laser array used in the optical condenser device of the first embodiment of the present invention.

[FIG. 4] is a perspective view of a cylindrical lens used in the optical condenser device of the first embodiment of the present invention.

[FIG. 5] is a perspective view of a light path converter used in the optical condenser device of the first embodiment of the present invention.

[FIG. 6] is a plan view showing an optical combiner used in the optical condenser device of the first embodiment

of the present invention.

[FIG. 7] is a diagram illustrating the conversion of the lights in the optical condenser device of the first embodiment of the present invention.

[FIG. 8] is a diagram illustrating combining of the beams by the optical condenser device of the first embodiment of the present invention.

[FIG. 9] is a schematic perspective view showing an optical condenser device of a second embodiment of the present invention.

[FIG. 10] is a diagram illustrating combining of lights by the optical condenser device of the second embodiment of the present invention.

[FIG. 11] is a perspective view of a semiconductor laser array.

[FIG. 12] is a diagram illustrating the angles of spread of a beam emitted from the semiconductor laser array.

[Explanation of Reference Numerals]

10: first light source; 12: first semiconductor laser array; 14, 24: active layer; 16: first cylindrical lens; 18: first light path converter; 20: second light source; 22: second semiconductor laser array; 26: second cylindrical lens; 28: second light path converter; 30: first optical combiner; 32: light transmitting portion; 34: light reflecting portion; 91: combined light.

[Document Name] ABSTRACT

[Abstract]

[Problem] An optical condenser device wherein beams emitted from active layers are difficult to cross each other even if the active layers of the semiconductor laser array are close to each other is provided.

[Means of Solution] An optical condenser device has light sources 10, 20 and an optical combiner 30. Each light source 10, 20 includes a semiconductor laser array 12, 22, a collimator lens 16, 26 and a light path converter 18, 28. The optical combiner 30 combines the beams from the light sources 10, 20. The spread of the beams in planes perpendicular to the direction of alignment of the active layers 14, 24 is restrained by the refraction of the collimator lenses 16, 26. The transverse sections of the respective beams are rotated by substantially 90° by the light path converters 18, 28. The spread of the beams in the direction of alignment of the active layers is thus restrained and crossing of adjacent beams becomes unlikely to occur.

[Selected Drawing] Figure 1